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(54) **METHOD AND APPARATUS FOR VISION AND NETWORK GUIDED PREFILTERING**

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H04N 19/117	(2014.01)
H04N 19/164	(2014.01)
H04N 19/17	(2014.01)

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CPC ***H04N 19/80*** (2014.11); ***H04N 19/115*** (2014.11); ***H04N 19/117*** (2014.11); ***H04N 19/164*** (2014.11); ***H04N 19/17*** (2014.11)

(58) **Field of Classification Search**

None

See application file for complete search history.

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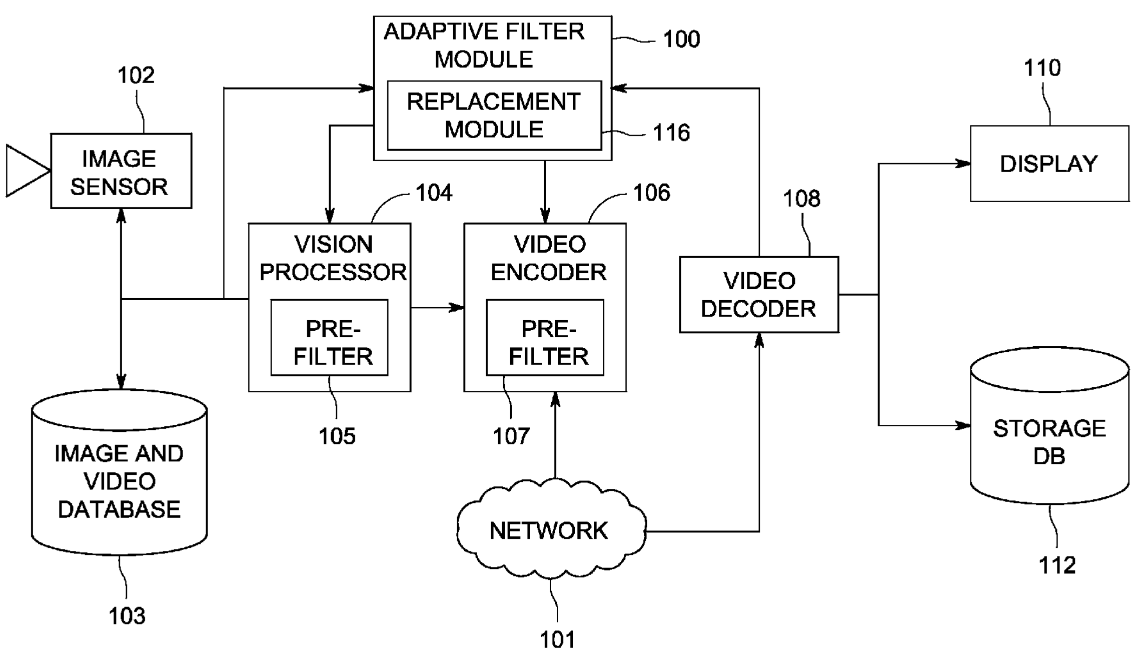
(57) **ABSTRACT**

A method for modifying bit-rate comprising receiving bandwidth information about a network, modifying one or more parameters of a pre-filter coupled to a video encoder based on the received bandwidth information, applying the pre-filter to video content based on the modified parameters and encoding the pre-filtered video content to have a bandwidth commensurate with the bandwidth information.

20 Claims, 6 Drawing Sheets



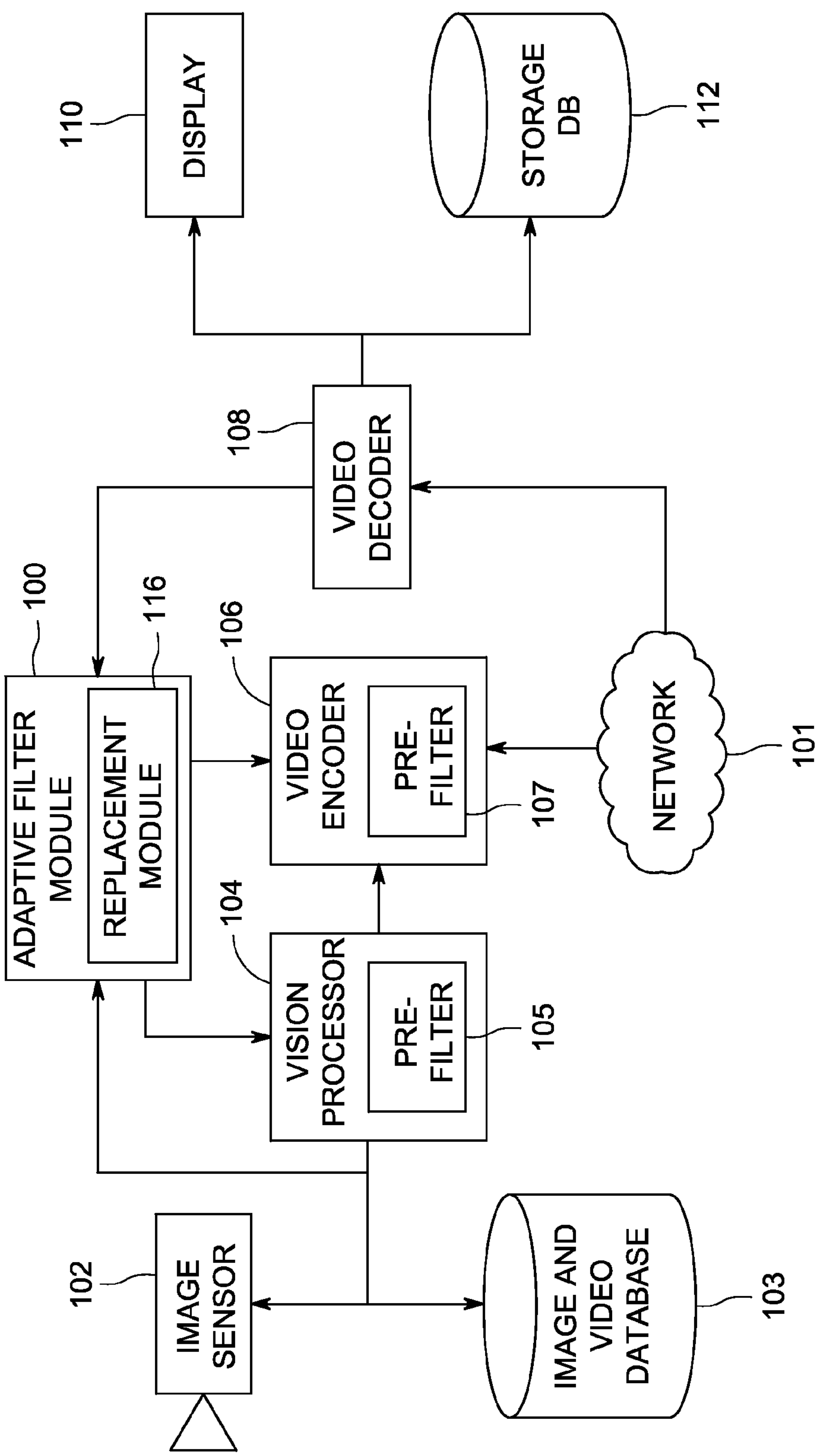

110
DISPLAY
STORAGE DB
112
108
VIDEO DECODER
100
ADAPTIVE FILTER MODULE
116
REPLACEMENT MODULE
106
VIDEO ENCODER
PRE-FILTER
107
NETWORK
101
104
VISION PROCESSOR
PRE-FILTER
105
102
IMAGE SENSOR
IMAGE AND VIDEO DATABASE
103

FIG. 1

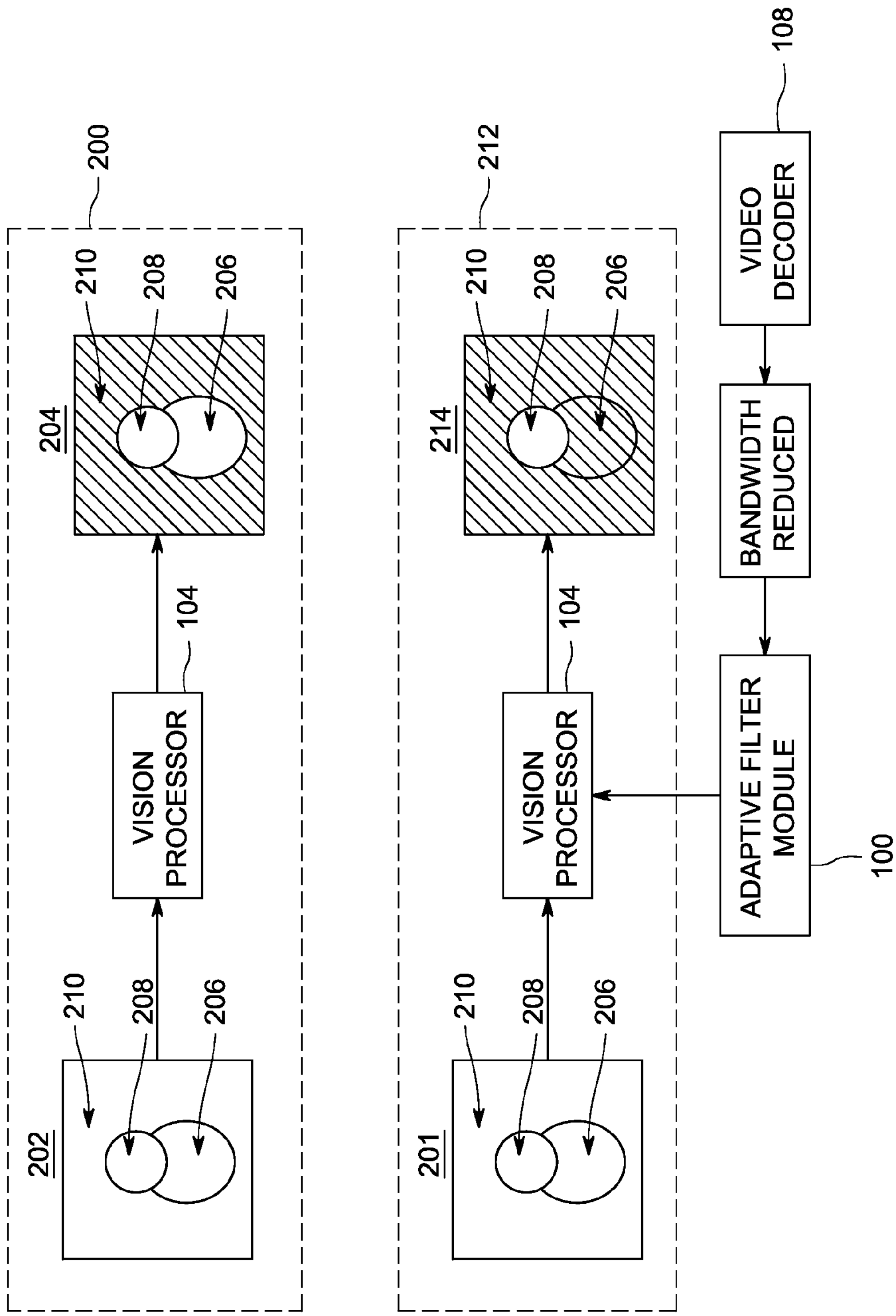

200
202
204
206
208
210
104
VISION PROCESSOR
212
201
214
206
208
210
104
VISION PROCESSOR
108
VIDEO DECODER
BANDWIDTH REDUCED
ADAPTIVE FILTER MODULE
100

FIG. 2

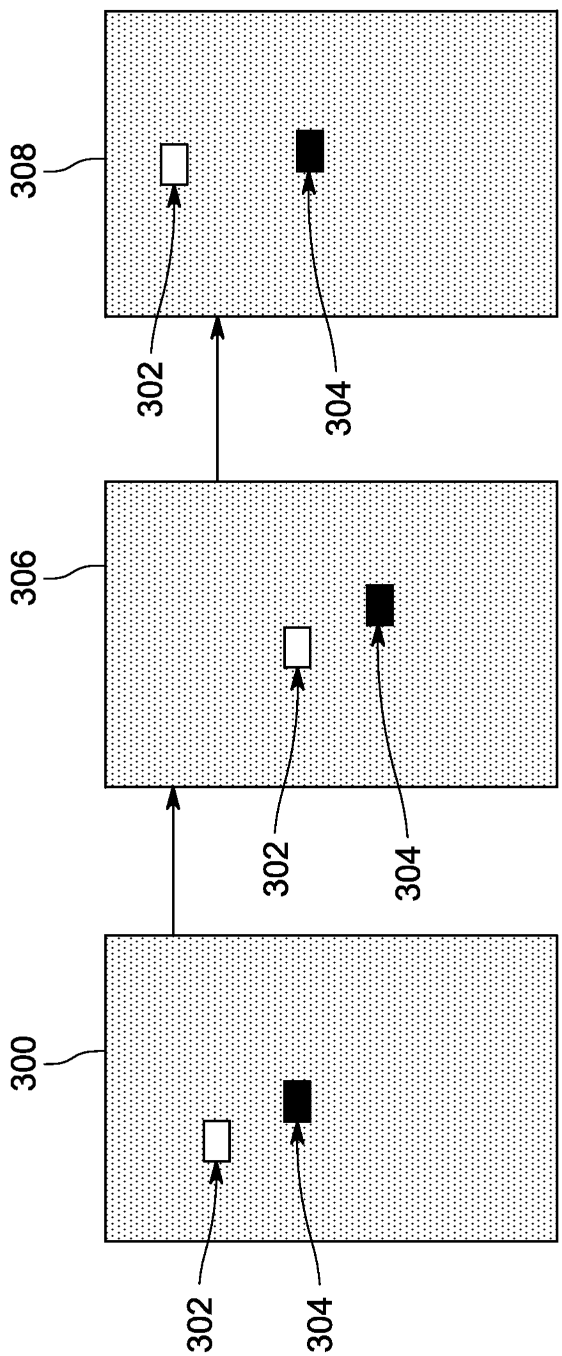


FIG. 3

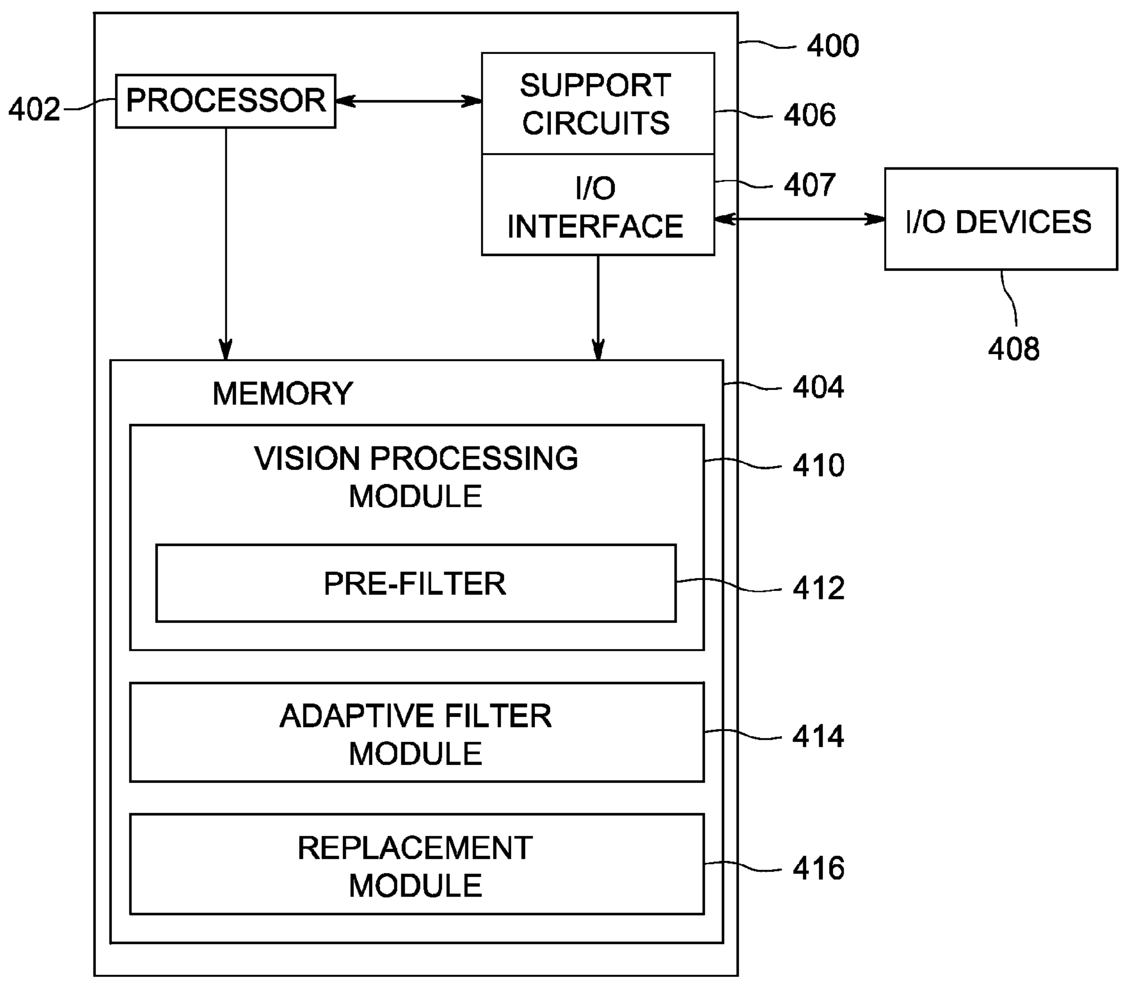

400
402
PROCESSOR
SUPPORT CIRCUITS
406
I/O INTERFACE
407
I/O DEVICES
408
MEMORY
404
VISION PROCESSING MODULE
410
PRE-FILTER
412
ADAPTIVE FILTER MODULE
414
REPLACEMENT MODULE
416

FIG. 4

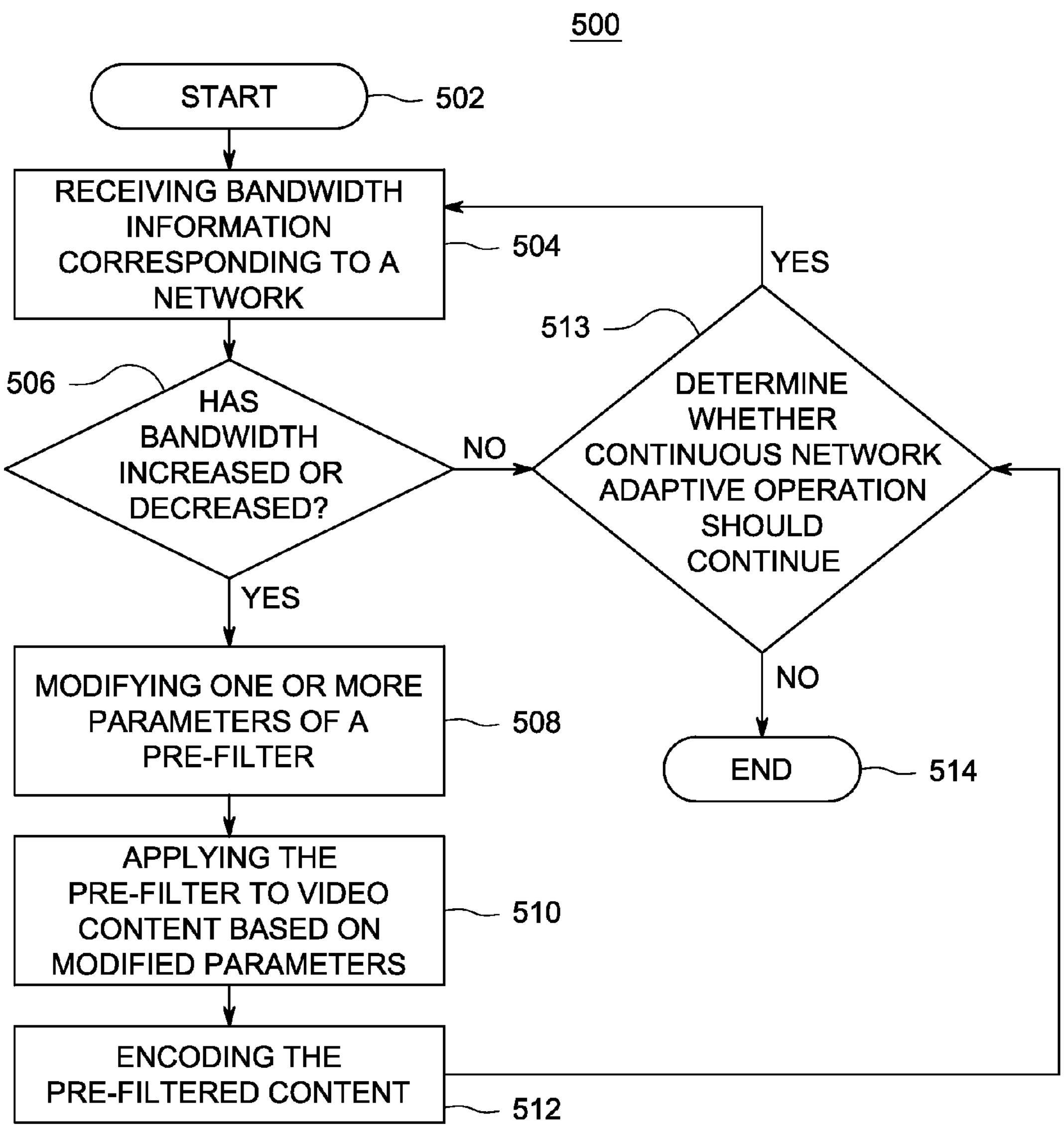

500
START
502
RECEIVING BANDWIDTH INFORMATION CORRESPONDING TO A NETWORK
504
506
HAS BANDWIDTH INCREASED OR DECREASED?
NO
YES
513
DETERMINE WHETHER CONTINUOUS NETWORK ADAPTIVE OPERATION SHOULD CONTINUE
YES
NO
END
514
MODIFYING ONE OR MORE PARAMETERS OF A PRE-FILTER
508
APPLYING THE PRE-FILTER TO VIDEO CONTENT BASED ON MODIFIED PARAMETERS
510
ENCODING THE PRE-FILTERED CONTENT
512

FIG. 5

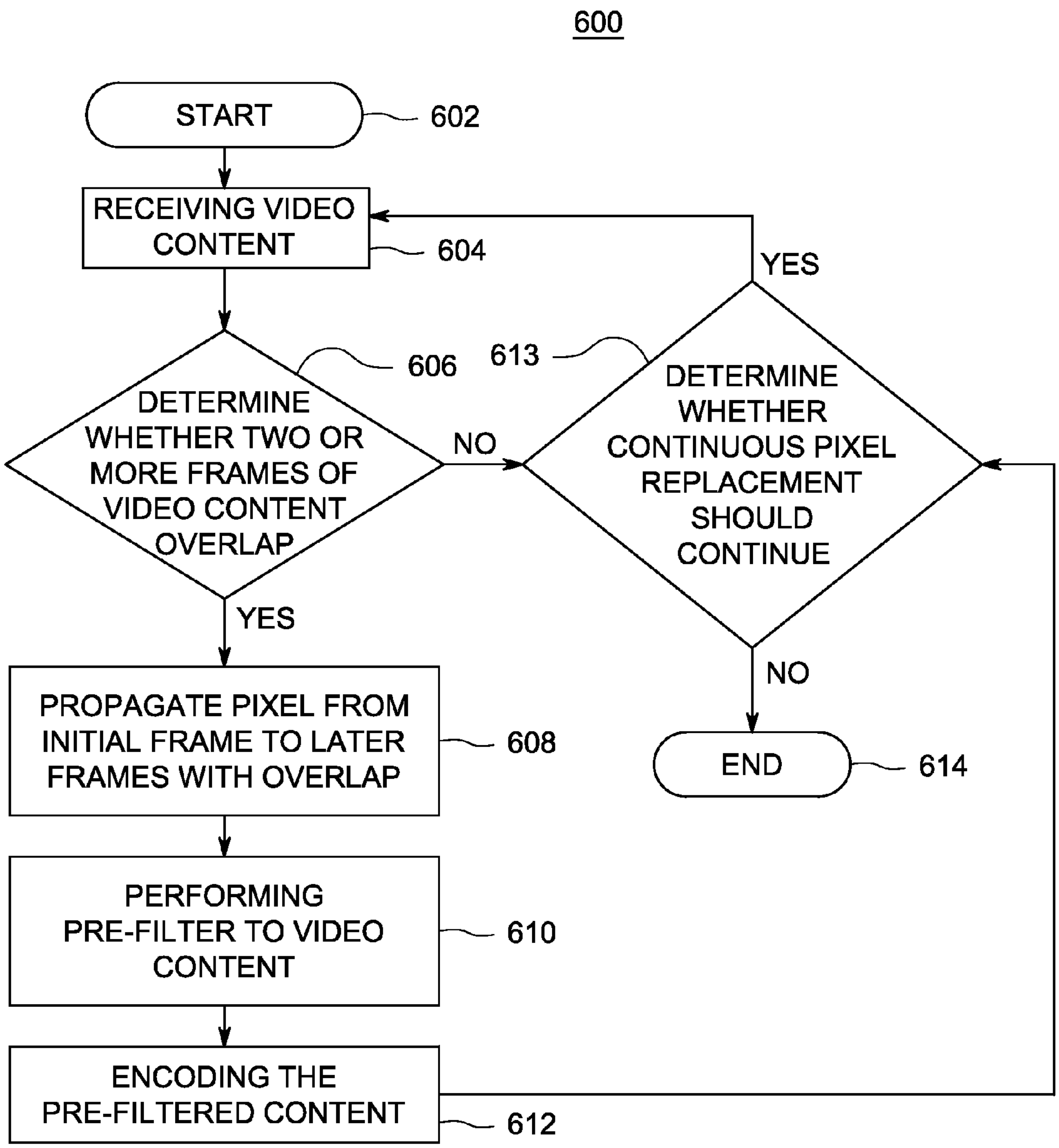

600
START
602
RECEIVING VIDEO CONTENT
604
DETERMINE WHETHER TWO OR MORE FRAMES OF VIDEO CONTENT OVERLAP
606
NO
YES
613
DETERMINE WHETHER CONTINUOUS PIXEL REPLACEMENT SHOULD CONTINUE
YES
NO
PROPAGATE PIXEL FROM INITIAL FRAME TO LATER FRAMES WITH OVERLAP
608
END
614
PERFORMING PRE-FILTER TO VIDEO CONTENT
610
ENCODING THE PRE-FILTERED CONTENT
612

FIG. 6

METHOD AND APPARATUS FOR VISION AND NETWORK GUIDED PREFILTERING

BACKGROUND OF THE INVENTION

1. Field of the Invention

Embodiments of the present invention generally relate to salience based compression and video transmission and, more particularly, to a method and apparatus for vision and network guided pre-filtering of video content.

2. Description of the Related Art

When video and image data is captured by a video sensor such as a video camera, the device often saves the video and image data in a compressed format to internal or external storage, or an external video database. Oftentimes, this video content is accessed across a network by various users or end-user devices. Before the content can be shared, however, the video must be encoded by a video encoder to compress the video further in order for the network bandwidth to support the transmission of the video. The video encoder modifies the bit-rate of the content according to the available bandwidth of the network and a video decoder decodes the video for displaying on a conventional display or for storage in another database. Technologies such as vision guided compression (VGC) or salience based compression (SBC) are often used to perform compression on video content to reduce bit rate so as to reduce network bandwidth requirements by preserving important and actionable details in the original video content in salient regions at the cost of discarding "unimportant" detail in non-salient regions. However, standard VGC/SBC methods do not address a network's variable bandwidth or delivering actionable video on very low bandwidth networks and therefore video streaming may be interrupted or distorted.

Therefore, there is a need in the art for a method and apparatus for vision and network guided pre-filtering to perform video encoding for low and variable bandwidth networks.

SUMMARY OF THE INVENTION

An apparatus and/or method for vision and network guided pre-filtering, substantially as shown in and/or described in connection with at least one of the figures, as set forth more completely in the claims.

Various advantages, aspects and features of the present disclosure, as well as details of an illustrated embodiment thereof, are more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

FIG. **1** depicts a functional block diagram of an adaptive filter module in accordance with exemplary embodiments of the present invention;

FIG. **2** is an illustration of the impact of the adaptive filter module on a sample frame of video content in accordance with an exemplary embodiment of the present invention;

FIG. **3** is an illustration of the result of the replacement module in accordance with exemplary embodiments of the present invention;

FIG. **4** depicts a computer in accordance with at least one embodiment of the present invention;

FIG. **5** depicts a flow diagram of a method for modifying bit-rate of video content in accordance with embodiments of the present invention; and

FIG. **6** depicts a flow diagram of a method for modifying bit-rate of video content in accordance with embodiments of the present invention.

DETAILED DESCRIPTION

Embodiments of the present invention generally relate to vision and network guided pre-filtering. According to one embodiment, an encoder encodes video for transmission over a network and a decoder receives the video and decodes the video for display, storage or the like. When the bandwidth of the network varies, the decoder utilizes a feedback pathway to modify encoder and pre-filter parameters to produce video content at a lower bit-rate. The pre-filter is applied to the video content to remove more non-salient regions, and the video content is further compressed by the encoder to deliver at a bandwidth matched to the network.

FIG. **1** depicts a functional block diagram of an adaptive filter module **100** in accordance with exemplary embodiments of the present invention. An image sensor **102** senses and captures video or images of a scene (not shown). The video or image content can also optionally be stored in an image and video database **103**, or stored in another form of external or internal storage. The image sensor **102**, for example, captures the video at a particular image size and frame rate. Video encoder **106** compresses video into such formats as MPEG-1 (H.261), MPEG-2 (H.262), MPEG-4/AVC (H.264) and MPEG HEVC (H.265), or the like. The originally captured frames may be in high definition (HD) or standard definition (SD), where even standard definition frames of a video may be several megabytes in size. The HD frames of video are significantly larger and occupy more storage space as well as require more bandwidth when being transmitted.

For example, for a video composed of SD frames, an acceptable target bit-rate may be 1-5 Mbps, whereas an HD video stream requires as much as 10-18 Mbps of network bandwidth to transmit video streams at their desired clarity. For commonly used networks such as network **101**, such large bandwidth requirements may be impractical and therefore, a vision processor **104** is embedded between the image sensor **102** and a video encoder **106**. Typical networks may include RF channels which have an approximate bandwidth of approximately 20 Megabits per second (Mbps), IP networks which have an approximate bandwidth of 0.1 to 5 Mbps, and the like.

The vision processor **104** further comprises a pre-filter **105**. The vision processor **104** applies vision guided pre-filtering (VGP)/salience based pre-filtering (SBP) to the video content to facilitate automatic reduction of the bit-rate of the video content without losing important detail. The vision pre-filter **105** performs salience based pre-filtering or other functions on the video content. For example, if the video content contains two moving objects on a background, the moving objects are detected and regarded as salient, and the background is considered non-salient.

The non-salient regions are then filtered, by various filters such as a Gaussian filter, a boxcar filter, a pillbox filter, or the like, removing a significant amount of unimportant detail that would have required many bits to encode. For further detail regarding SBC/VGC, please see commonly assigned and co-pending U.S. patent application Ser. No. 12/644,707 entitled "High-Quality Region-Of-Interest Compression using commercial Off-The-Shelf encoders", filed on Dec. 22, 2009, hereby incorporated by reference in its entirety.

The video encoder **106** encodes the compressed video content using the compression standards mentioned above, such as MPEG2/MPEG4, or the like. The video encoder **106** may further comprise a pre-filter **107** which performs pixel-level filtering, but does not take into account salient attributes of the video content, as opposed to the vision processor **104**, which does. The video encoder **106** is a standard, off-the-shelf video encoder. The video encoder encodes the video in order to transmit the video at a particular bit-rate over the network **101**.

In order for the video content to be viewed, it must first be decoded by the video decoder **108**. As with the video encoder **106**, the video decoder **108** is a standard off-the-shelf video decoder capable of decoding standard video formats such as MPEG2/MPEG4, or the like. Once the decoder decodes the video content, the content is streamed or transmitted to a display **110**, or to a storage database **112**. According to other embodiments, the video decoder **108** can couple the video content with any end user consuming device such as a tablet, a mobile phone, a television, or the like.

In some instances, the network **101** may experience slowdown because of other users, or various environmental conditions. In other instances, the network **101** may be a low bandwidth network such as those available in the field. In these instances, more aggressive encoding of video content is highly desired to decrease bit-rate and keep video content streaming continuously without losing actionability, and maintaining the visibility of spatially salient regions of the video content.

In a closed network, a feedback path is present between the video decoder **108** and the vision processor **104**. The video decoder **108** receives information about network bandwidth changes and couples with the adaptive filter module **100** to send a message to the vision processor **104** about the changed network bandwidth.

The adaptive filter module **100** then determines how the vision processor **104** and the pre-filter **105** will be modified to increase or decrease the bit-rate depending on whether the network bandwidth has increased or decreased, respectively. The adaptive filter module **100** may, according to one embodiment, request that the pre-filter **105** modify the type of filter being applied, for example, a boxcar, a Gaussian filter or a pillbox filter. According to other embodiments, the filter size and/or frequency response is modified. For example, a smaller or larger region is filtered according to the bit-rate requirements. According to another embodiment, the number of salient objects being filtered is modified according to location, size of objects, amount of motion, or the like. According to yet another embodiment, the adaptive filter module **100** requests that the vision processor **104** and the pre-filter **105** vary the rate in which the filter is applied to salient objects. The degree of low-pass filtering applied to non-salient pixels in a frame greatly affects the bit rate. For a given low-pass filter shape, the degree of filtering increases with filter size.

For example, for a box-car filter applied to video processed by a binary salience map drastically reduces the bit-rate as the filter increases in size. For example, a 640×480 pixel video running at 30 frames per second is filtered with a boxcar filter and encoded in "constant quality" mode using H.264/MPEG-4 AVC video compression. In constant quality mode, the quantization parameter (QP) stays fixed, and bits are produced in proportion to the underlying entropy of the video signal. As QP increases, more transform coefficients are quantized to zero, and fewer coded bits per image block are produced. Major drops in bit rate, independent of QP, occur as the boxcar size increases from 1×1 to 5×5, with diminishing returns thereafter. Boxcar sizes larger than 9×9 show almost no additional drop in bit rate, for typical video content. The resulting bit rate is approximated as a weighted average of the two extremal bit rates produced when all pixels are filtered by each of the filters individually:

$$BR=W^*BR_{max}+(1-W)^*BR_{min} \tag{1}$$

where BR_{max} is the bit rate produced by filtering all pixels with the salient, on "inside", filter; BR_{min} is the bit rate produced by filtering all pixels with the non-salient, on "outside", filter; and W, the weighting parameter, is equal to the fraction of salient pixels in the frame. In this example, when video is filtered with a 1×1 boxcar (i.e., is not filtered at all) and encoded in constant quality mode with QP=20, the resulting bit rate is BR_{max}=8 Mbps. When the same video is filtered with an 11×11 boxcar and encoded in constant quality mode with QP=20, the resulting bit rate is BR_{min}=1 Mbps. When the fraction of salient pixels in the frame is 10% (W=0.1), the resulting bit rate is approximately BR=0.1*8+0.9*1=1.7 Mbps. As W approaches 1.0, BR approaches BR_{max}; as W approaches 0.0, BR approaches BR_{min}.

Accordingly, increasing the filter size lowers the bit rate. For instance, if the channel bit rate is 3 Mbps, a 3×3 boxcar filter is used; however, if the channel bit rate drops to 1 Mbps, an 11×11 boxcar filter is selected. Doing so increases the blur of the non-salient pixels but minimally affects the quality of the salient pixels.

Generally speaking, the bit rate can be modeled as the following exponential function of filter size:

$$r(s)=a\cdot\exp(-bs)+c \tag{2}$$

where exp( ) is the exponential function, r is the rate in bits per second (bps), s is the filter size (in pixels) and a, b, and c are known, non-negative, measured constants that are a function of image format and content. For a two-level salience map, the rate R produced by filtering some non-negative fraction α_1 of the pixels with size s_1 and the complementary non-negative fraction $\alpha_2=1-\alpha_1$ with size s_2 is given by:

$$R=\alpha_1 r(s_1)+\alpha_2 r(s_2)=[\alpha_1\cdot a\cdot\exp(-bs_1)+c]+[\alpha_2\cdot a\cdot\exp(-bs_2)+c] \tag{3}$$

We know R, α_1, α_2, a, b and c, so the equation reduces to

$$C=\alpha_1 x_1+\alpha_2 x_2 \tag{4}$$

where C=(R−2c)/a and $x_i=\alpha_i\cdot\exp(-bs_i)$ for i=1, 2. This is a linear equation in x_1,x_2 so any two values satisfying the equation can be picked. Once they are picked, the filter sizes are obtained as follows:

$$s_i=-\ln(x_i/\alpha_i)/b \text{ for } i=1,2 \tag{5}$$

where ln( ) is the natural log function. In practice, s_i would be rounded to the nearest integer. Although this formulation is for the two-level saliency case (N=2), it is straightforward to generalize this method to the N-level saliency case, where N>2. Filter sizes and filter kernels can either be generated adaptively or pre-computed and stored in a look-up table stored in the adaptive filter module **100**. According to an exemplary embodiment, filter sizes increase as network bandwidth decreases, and less filtering is done in salient regions compared to non-salient regions.

According to other embodiments, the adaptive filter module **100** may also comprise a replacement module **116**, which may be directly coupled with the image sensor **102**, the image and video database **103**, the vision processor **104** an the video encoder **106**. In some instances, the replacement module **116** can be used independently of the adaptive filter module **100**.

According to one embodiment, the replacement module **116** receives video content from the image sensor **102**, for example, and analyzes frame to frame movement in the captured video content. In scenes where the sensor **102** view is relatively fixed, but there is some movement of the sensor **102**, video stabilization is initially performed in order to align the frames in the video content. Once the frames are aligned, the replacement module **116** analyzes frame to frame pixel differences in the video content and determines the pixels which remain static in the sense that they do not need to be changed in each frame.

The replacement module **116** then selectively copies the pixels found in the initial frame to the other frames which share an overlapping view of the initial frame. When the video encoder **106** directly performs compression on the selectively modified video content, it achieves better compression ratio than on the unmodified video because each of the frames are largely composed of the identical pixels, excluding any moving object pixels. The highly compressed video content can therefore be transmitted over low bandwidth networks. The video is decoded by video decoder **108** and displayed on display **110** with most of the background remaining static while only foreground, or salient, objects are in motion.

According to some embodiments, the frame-to-frame pixel operations can be achieved by stabilizing, ortho-rectifying, warping the imagery (including parallax correction) and ensuring that the overlapping pixels corresponding to the background do not change from frame to frame. Because of the predictive nature of all modern video codecs, including, but not limited to, MPEG-2, H.263, H.264, and High Efficiency Video Coding (HEVC) standard, the bit rate for the compressed video will be noticeably reduced compared to the video that has not been pre-processed due to the fact that, except for small overhead to convey static areas, bits will only need to be spent on coding the moving objects.

According to further embodiments, if a field of view of two or more frames does not differ or substantially overlaps, any areas containing identical pixels can be located and copied from frame to frame, regardless of whether the pixels are considered foreground or background objects, salient or non-salient objects. For example, if an object is moving in the video content, but the pixels corresponding to the object do not differ from frame to frame in terms of their color/shape, then those pixels may also be replaced with a simple copy and paste operation from an earlier frame into the new location(s) for the subsequent frame(s).

FIG. **2** is an illustration of the impact of the adaptive filter module **100** on a sample frame of video content in accordance to an exemplary embodiment of the present invention. Illustration **200** depicts the typical scenario where an image frame **202** comprises a torso **206**, a head **208** and a background **210**. The vision processor **104** is applied to the frame of the video content to produce a salience detected image where the torso **206** and the head **208** are determined as salient and the background **210** is determined as non-salient. The background **210** has had a filter applied to it, for example, a Gaussian blur, in order to reduce the amount of detail shown, whereas the torso **206** and the head **208** are maintained at their current fidelity or sharpened.

However, when the adaptive filter module **100** receives notification that the bandwidth has been reduced from the video decoder **108**, the vision processor **104** behaves differently. According to this embodiment, illustration **207** shows the same frame **201** being processed by the vision processor **104**, but the output image **214** has produced only one salient object: the head **208**. The vision processor has filtered the torso **208** and the background **210** by, according to one embodiment, reducing the number of salient objects to be produced by the vision processor **104**, where the only salient object is the face **208**. In this embodiment, when the decoder decodes the video content and displays the frame **214** on a display, the body and background will be blurred and the foreground face **208** will be sharp. When the network bandwidth increases, then the adaptive filter module **100** will, for example, increase the number of salient objects again resulting in torso **206** and body **208** being shown.

FIG. **3** is an illustration of the result of the replacement module **116** in accordance with exemplary embodiments of the present invention. Frame **300**, frame **306** and frame **308** have two common objects, object **302** and object **304**. In addition, the background of each frame is essentially the same in terms of pixel coloration and the like. The replacement module **116** identifies that the only changes in pixels are the position of object **302** and object **304** as they move around the background area, but the background remains static because the replacement module **116** uses pixels of the background in frame **300** and copies them to frame **306** and **308**.

According to other embodiments of the present invention, the replacement module **116** further may be given the information that the objects **302** and **304** are the same objects in frame **306** and **308**. The replacement module **116** can make a further change and copy the pixels of object **302** and **304** from frame **306** and paste those same pixels in frame **306** and **308** at their correct new positions. Therefore, when the encoder **106** performs encoding, compression will be greatly increased and bit-rate will be significantly reduced because frame **306** and frame **308** have nearly the same pixels as frame **300**.

FIG. **4** depicts a computer **400** in accordance with at least one embodiment of the present invention. The computer **400** includes a processor **402**, various support circuits **406**, and memory **404**. The processor **402** may include one or more microprocessors known in the art. The support circuits **406** for the processor **402** include conventional cache, power supplies, clock circuits, data registers, I/O interface **407**, and the like. The I/O interface **407** may be directly coupled to the memory **404** or coupled through the supporting circuits **406**. The I/O interface **407** may also be configured for communication with input devices and/or output devices such as network devices, various storage devices, mouse, keyboard, display, video and audio sensors, IMU and the like.

The memory **404**, or computer readable medium, stores non-transient processor-executable instructions and/or data that may be executed by and/or used by the processor **402**. These processor-executable instructions may comprise firmware, software, and the like, or some combination thereof. Modules having processor-executable instructions that are stored in the memory **404** comprise a vision processing module **410**, an adaptive filter module **414** and a replacement module **416**. The vision processing module **410** further comprises a pre-filter **412**. According to some embodiments, the replacement module **416** may be a portion of the adaptive filter module **414**.

The computer **400** may be programmed with one or more operating systems (generally referred to as operating system (OS)), which may include OS/2, Java Virtual Machine, Linux, SOLARIS, UNIX, HPUX, AIX, WINDOWS, WINDOWS95, WINDOWS98, WINDOWS NT, AND WINDOWS2000, WINDOWS ME, WINDOWS XP, WINDOWS SERVER, WINDOWS 8, Mac OS X, IOS, ANDROID among other known platforms. At least a portion of the operating system may be disposed in the memory **404**.

The memory **404** may include one or more of the following random access memory, read only memory, magneto-resistive read/write memory, optical read/write memory, cache memory, magnetic read/write memory, and the like, as well as signal-bearing media as described below.

FIG. **5** depicts a flow diagram of a method **500** for modifying bit-rate of video content in accordance with embodiments of the present invention. The method **500** is an implementation of the adaptive filter module **414** and the vision processing module **410** as executed by the processor **402** by the computer system **400** as shown in FIG. **4**.

The method begins at step **502** and proceeds to step **504**. At step **504**, the adaptive filter module **414** receives information corresponding to network bandwidth from a video decoder. According to some embodiments, the video decoder transmits information about changes in the bandwidth. According to other embodiments, the video decoder transmits network bandwidth information continuously, and the adaptive filter module **414** behaves accordingly.

The method proceeds to step **506**, where the adaptive filter module **414** determines whether bandwidth has increased or decreased, i.e., whether bandwidth has changed. If bandwidth has not changed, the method ends at step **514**. If the adaptive filter module **414** determines that bandwidth has increased or decreased, the method proceeds to step **508**. At step **508**, the method **500** modifies one or more parameters of pre-filter **412** of the vision processing module **410**. As described above, the pre-filter may be a low-pass filter for performing functions such as blurring based on salient object determination by the vision processing module **410**.

The vision processor **410** then applies the pre-filter **412** to video content being transmitted at step **510**, based on the modified parameters to reduce the bit-rate of the video content. For example, if the bandwidth of the network had decreased, the adaptive filter module **414** modifies increases the filter size so as to drive down the bit-rate. At step **510**, an encoder, such as the video encoder **106**, encodes the video applying a compression scheme such as MPEG2, MPEG 4, or the like. At step **513**, the method **500** determines whether continuous network adaptive operation should proceed, and if continuous network adaptive operation should proceed, the method **500** returns to step **504**. If, at step **513**, there is a request to terminate the method **500**, the method **500** then terminates at step **514**.

FIG. **6** depicts a flow diagram of a method **600** for modifying bit-rate of video content in accordance with embodiments of the present invention. The method **600** is an implementation of the replacement module **416**, the adaptive filter module **414** and the vision processing module **410** as executed by the processor **402** by the computer system **400** as shown in FIG. **4**.

The method begins at step **602** and proceeds to step **604**. At step **604**, replacement module **416** receives video content. At step **606**, the replacement module **416** determines whether in two or more frames of the video content, whether a field of view overlaps, or significant amounts of pixels overlap. For example, the replacement module **416** may use various means to detect one or more objects **302** and **304** in frame **300** as shown in FIG. **3**, as well as a similar background in frames **300**, **306** and **308**.

At step **608**, the replacement module **416** copies the pixels of the initial frames, for example, Frame **300** of FIG. **3**, of the video content to the later frames in the video content in which field of view, content, or background overlap, such as frames **306** and **308** of FIG. **3**. At step **610**, the vision processor **410** applies the pre-filter **412** to the received video content. The video encoder **106**, for example, performs video encoding on the video content at step **612**. At step **613**, the method **600** determines whether continuous pixel replacement should continue. If it is determined that pixel replacement should continue, the method returns to step **604**, otherwise, the method terminates ate step **614**.

Various elements, devices, modules and circuits are described above in association with their respective functions. These elements, devices, modules and circuits are considered means for performing their respective functions as described herein. While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

The invention claimed is:

1. A method for vision and network guided pre-filtering of video content comprising:

receiving bandwidth information about a network via a feedback path;

modifying one or more parameters of a pre-filter coupled to a standard video encoder based on the received bandwidth information, the video encoder configured to encode video at a bit-rate commensurate with activity in a region of the video content; and

applying the pre-filter to video content based on the modified one or more parameters to generate pre-filtered video content, wherein the pre-filter facilitates saliency based compression by recognizing salient regions and non-salient regions in the original video content; and

wherein salient regions in the pre-filtered video content are automatically encoded at a higher bit-rate than non-salient regions.

2. The method of claim **1** further comprising:

wherein the parameters comprise at least one of filter type, filter size, filter response, number of salient objects or rate of filter application to the salient objects.

3. The method of claim **2** further comprising:

modifying the filter type between one of boxcar, Gaussian or pillbox filters.

4. The method of claim **2** further comprising:

performing one or more of increasing the filter size and reducing a lowpass cutoff frequency of the filter to a predetermined limit when the bandwidth decreases in order to decrease a bit-rate of the video content; and

performing one or more of decreasing the filter size and increasing the lowpass cutoff frequency of the filter when the bandwidth increases in order to increase a bit-rate of the video content.

5. The method of claim **2** further comprising:

increasing the number of salient objects when bandwidth of the network increases to increase a bit-rate of the video content; and

decreasing the number of salient objects when the bandwidth decreases to decrease a bit-rate of the video content.

6. The method of claim **1** further comprising:

determining whether non-salient regions of the original video content remain nearly static; and

replacing pixels in the non-salient region in the original video content from frame to frame with pixels from an initial frame in the video content before pre-filtering the video content.

7. The method of claim **6** wherein replacing pixels further comprising:

performing one or more of frame to frame ortho-rectification, frame stabilization, frame warping to ensure pixels corresponding to non-salient regions are unchanging from frame to frame in the video content.

8. The method of claim **6** further comprising:

performing background stabilization of the video content before determining whether non-salient regions of the video content remain nearly static.

9. The method of claim **1** wherein the encoding is performed by a standard off-the-shelf encoder.

10. An apparatus for vision and network guided pre-filtering of video content comprising:

an adaptive filter module, coupled to a video sensor, for receiving bandwidth information about a network via a feedback path and modifying one or more parameters of a pre-filter coupled to a video encoder based on the received bandwidth information, the video encoder configured to encode video content at a bit-rate commensurate with activity in a region of the video content; and

a vision processor, coupled to the adaptive filter module, for applying the pre-filter to video content based on the modified one or more parameters, wherein the pre-filter facilitates saliency based compression by recognizing salient regions and non-salient regions in the video content,

wherein salient regions in the pre-filtered video content are automatically encoded at a higher bit-rate than non-salient regions.

11. The apparatus of claim **10** further comprising:

wherein the parameters comprise at least one of filter type, filter size, filter response, number of salient objects and rate of filter application to salient objects.

12. The apparatus of claim **11** wherein the adaptive filter module is further configured for modifying the filter type between one of boxcar, Gaussian or pillbox filters.

13. The apparatus of claim **11** wherein the adaptive filter module is further configured for:

performing one or more of increasing the filter size and reducing a lowpass cutoff frequency of the filter to a predetermined limit when bandwidth of the network decreases in order to decrease a bit-rate of the video content; and

performing one or more of decreasing the filter size and increasing the lowpass cutoff frequency of the filter when the bandwidth increases in order to increase a bit-rate of the video content.

14. The apparatus of claim **11** wherein the adaptive filter module is further configured for:

increasing the number of salient objects when bandwidth of the network increases to increase a bit-rate of the video content; and

decreasing the number of salient objects when the bandwidth decreases to decrease a bit-rate of the video content.

15. The apparatus of claim **10** wherein the video encoder is a standard off-the-shelf encoder.

16. A non-transitory computer-readable medium containing program instructions for causing a computer to perform a method comprising:

receiving bandwidth information about a network via a feedback path; modifying one or more parameters of a pre-filter coupled to a standard video encoder based on the received bandwidth information, the video encoder configured to encode video content at a bit-rate commensurate with activity in a region of the video content; and

applying the pre-filter to video content based on the modified one or more parameters to generate pre-filtered video content, wherein the pre-filter facilitates saliency based compression by recognizing salient regions and non-salient regions in the video content; and

wherein salient regions in the pre-filtered video content are automatically encoded at a higher bit-rate than non-salient regions.

17. The computer-readable medium of claim **16**, wherein the parameters comprise at least one of filter type, filter size, filter response, number of salient objects and rate of filter application to salient objects.

18. The computer-readable medium of claim **17** wherein the method further comprises:

performing one or more of increasing the filter size and reducing a lowpass cutoff frequency of the filter to a predetermined limit when bandwidth of the network decreases in order to decrease a bit-rate of the video content; and

performing one or more of decreasing the filter size and increasing the lowpass cutoff frequency of the filter when the bandwidth increases in order to increase a bit-rate of the video content.

19. The computer-readable medium of claim **17** wherein the method further comprises:

increasing the number of salient objects when bandwidth of the network increases to increase a bit-rate of the video content; and

decreasing the number of salient objects when the bandwidth decreases to decrease a bit-rate of the video content.

20. The computer-readable medium of claim **16** wherein the encoding is performed by a standard off-the-shelf encoder.

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